Go Back

Condition Assessment Technique for Commissioning/Recommissioning of Army HVAC Control Systems

Draft - 18 January 1999

TABLE OF CONTENTS

Recommissioning of Army HVAC Control Systems
(**Condition Assessment Technique**)
Draft - 18 January 1999

1. Introduction.

This document describes a technique for performing a condition assessment (CA) of the heating, ventilating, and air conditioning (HVAC) control systems in Army buildings. The intended users:

- Corps of Engineers District designers and Area Office staff,
- Engineering Plans and Services (EP&S) engineers,
- Department of Public Works (DPW) operation and maintenance mechanics.

A condition assessment of a buildings HVAC control systems is performed to determine if the controls are operating properly and to identify fixes. In some cases, fixes can be implemented during the CA process. CA can be done on existing buildings as part of a recommissioning effort or as part of the building commissioning process as defined in part in HVAC Systems Commissioning Corps of Engineers Guide Specifications (CEGS-15995). This document focuses on recommissioning, but is largely applicable to the commissioning process too.

This work is being done in conjunction with other USACERL research and development on commissioning and recommissioning of Army facilities and is funded primarily through the RDTE (AT45) program leveraged with reimbursable funds from various Army installations and HQ Forces Command (FORSCOM). USACERL is coordinating this effort with Louisville District (CELRL) and Fort Campbell Public Works, Fort Campbell Kentucky.

2. Background.

Commissioning (Cx) a building system, according to ASHRAE Guideline 1-1996, is the process for achieving, verifying, and documenting the performance of that system to meet the operational needs of the building within the capabilities of the design and to meet the design documentation and the owner's functional criteria, including preparation of operator personnel."[1,5] Building commissioning, therefore, applies to NEW construction projects.

Recommissioning (ReCx) is the process of adjusting, calibrating and repairing EXISTING building energy systems so that the equipment performs as optimally as possible for the current building usage within the constraints of the existing design. The extent that ReCx is performed on a given building depends on the current condition, owner(s) desires, and out-year plans of the facility. Major renovation of building energy systems is usually beyond the scope of ReCx. ReCx of HVAC systems usually places emphasis on the HVAC control system controllers, logic/sequences, instrumentation, and controlled devices.

Proper commissioning of HVAC equipment can avoid energy penalties of 10 to 35%[1,2]. Analysis of previous ReCx projects indicates paybacks in as short as one to four years[1,3]. On average, for seven mid-sized office buildings studied, a 15% energy savings can be achieved simply by operating existing equipment in accordance with the design intent[1,4].

Proper Cx and/or ReCx can also reduce maintenance costs, improve overall operation and maintenance, reduce construction change orders, and, most importantly, improve the building environment thus increasing worker productivity.[1] Because worker costs (salary and benefits) are typically 100 times the cost of energy and O&M for a building, even a small increase in worker productivity can substantially reduce costs.

3. Condition Assessment Technique.

CA Summary

a. Assemble a condition assessment toolkit.

b. Assemble Condition Assessment (CA) Team; District and Area Office, chief of DPW O&M, DPW shop foremen, and building operations manager.

c. Coordinate with CA Team members and select CA sites. Interview Area Office POC, DPW O&M staff, building operations manager.

d. Obtain access to as-built and/or design documentation from mechanical room, O&M staff, EP&S.

e. Visit site. Perform visual checks. Analyze and verify the HVAC controls sequence of operation in all possible modes, noting incomplete descriptions and logic faults. Check device set points and look for signs of a manually operated system.

f. Take copious notes.

g. Use data loggers where appropriate as both a diagnostic tool and as a means to quantify and verify the impact of correct performance.

h. Develop Condition Assessment Summary including a description of the benefits/energy cost savings.

i. Develop and implement a Get Well Plan.

CA Details

a. Assemble a condition assessment toolkit. The required tools will depend on the level of the condition assessment and the type of system(s) to be assessed. Tool selection considerations include: electric or pneumatic type controls, VAV or constant volume system, humidity or no humidity control. Recommended toolkits are listed below. Additional tool information is available from the CERL Commission*pedia* CD-ROM (available approximately 2Q FY00)- POC: Dahtzen Chu, 1-800-USA-CERL, ext.6784).

i. Basic toolkit:

- **$** Flashlight
- **$** Multi-tool (combination pliers, screw driver, etc.)
- **$** Notepad
- **$** Personal safety gear (hard hat, hearing protection, first aid kit)

ii. Advanced toolkit (Basic Toolkit plus):

- **$** Multimeter
- **$** Two-way radios
- **$** Calibration test kit (RTD simulator and 4-20 mA signal generator)
- **$** Handheld digital or dial gage thermometer
- **$** Pete=s plug temperature and pressure sensors
- **$** Jewelers screwdrivers (flat tip)
- **$** Screwdrivers (flat/Phillips)
- **$** Nut driver set
- **$** Linesmen pliers
- **$** Adjustable wrench
- **$** Mirror on a stick
- **$** Permanent marker

iii. Specialty toolkit items:

- **$** Data loggers, software, and laptop computer
- **$** Flow hood
- **$** Pitot tube/manometer or anemometer airflow measurement instrument
- **$** Differential pressure instrument (0 to 5 iwc)
- **$** Humidity measurement instrument
- **$** Air pressure regulator kit (with assorted pneumatic fittings)
- **$** Tachometer (strobe type)
- **$** Harmonics analyzer or ammeter
- **$** Cordless drill with universal bit
- **$** Tape measure

iv. Other useful items:

- **$** Equipment manufacturer reference:

-Heating/Piping Air Conditioning (HPAC) Engineering magazine AInfo-dex@ issue. Contains manufacturer phone numbers.
-The (Air Conditioning, Heating, and Refrigeration) NEWS ADirectory and Source Guide@ issue. (Published in January). Contains manufacturer phone numbers.

$ SMACNA Testing Adjusting and Balancing (TAB) manual
$ Associated Air Balance Council (AABC) TAB manual
$ RTD resistance to temperature conversion tables
$ *ReCx Energy Cost Savings* Spreadsheet (under development)
$ *HVAC Controls Calculations* Spreadsheet (under development)

b. Assemble Condition Assessment (CA) Team; District and Area Office, chief of DPW O&M, DPW shop foremen, and building operations manager. This may require solicitation of the installation's interest in performing condition assessments. Decide who will perform the condition assessment. A team of two may be ideal including a designer and a mechanic. You may choose to hire a contractor to perform the condition assessment.

c. Coordinate with CA Team members and select CA sites. Interview Area Office POC, DPW O&M staff, building manager. The installation will likely know which buildings are in most need of condition assessment. Develop a list of these including the symptoms. Keep everyone in the loop.

d. Obtain access to as-built and/or design documentation from mechanical room, O&M staff, EP&S. Obtaining documentation can be somewhat time consuming. Plan for this. Keep track of borrowed materials.

e. Visit site. Perform visual checks. Identify control panel, controlled devices, and sensors. Visually inspect condition of mechanical and electrical equipment. **Analyze and verify the HVAC controls sequence of operation** in all possible modes, noting incomplete descriptions and logic faults. Check device set points and look for signs of a manually operated system.

A list of things to check (based on site visits performed by CERL and a recent Portland Energy Conservation, Inc. publication[10)]):

i. Non-functioning air-side economizer. This is potentially one of your biggest energy saving controls. It may not work for a variety of reasons. Check to make sure it activates. Some economizers are activated based on return air temperature. If this activation setpoint is too high the economizer may never turn on. A limited swing in return air temperature (RAT) sometimes proves RAT to not be a good indicator of a buildings need for cooling. Activation of the economizer during the winter can cause tripping of the freeze stat (particularly in a single-zone system without a mixed air control loop).

ii. Systems that operate 24 hours/day, 365 days/year. This can be a big energy consumer. This may be evidenced by motor controls found operating in Ahand@ control mode or by time clocks that are not programmed or are overridden. In some cases, buildings are operated 24/365 due to O&M staff belief that buildings will not recover from unoccupied mode shutdown. In some cases this may be the case, possibly due in part to an undersized system. In other cases it may be due to O&M mechanic fear (based on their experience with some improperly functioning controls) that once a system is turned off it will not turn back on.

iii. Manually controlled systems. This includes manual control of shutoff valves, to control heating and cooling modes, where automatic control was intended. Check for manual positioning of automatic control valves and dampers. Check valve and damper linkages by modulating controlled devices full range. Do they move at all? Do they actuate smoothly over their full range of motion without bumping, binding, or twisting?

iv. Improper sequencing. Do the control drawings (Equipment Schedule) indicate that valves and/or dampers are to be sequenced to avoid simultaneous heating and cooling? If so, determine if the actuators have zero and span adjustments to provide for simultaneous heating and cooling. Look for other signs of simultaneous heating and cooling.

v. Improper tuning of proportional, integral, and derivative (PID) controllers. Look for settings consistent with those shown in Appendix XXX. Where multiple devices are controlled (sequenced) by a single control signal Proportional Band and Integral settings should be larger than those shown in the attachment. If two devices are controlled in sequence, the settings should be doubled. If three devices are controlled in sequence, the settings should be tripled.

vi. Short cycling of equipment leading to premature failure. This includes air compressors that run more than 20 minutes per hour (symptomatic of an air leak) resulting in possible oil carryover into the pneumatic air supply.

vii. Sensors. Problems with sensors including but not limited to: Improper installation, particularly low limit (freeze stats) where the elements are not serpentined, incorrect transmitter ranges such as ranges that are much too wide and/or too narrow for the application, sensors that are not accurate/calibrated, filter differential pressure switches and/or automatic filter advance mechanisms that don=t work.

viii. Lack of documentation. To properly operate and maintain a control system, consisting of numerous pieces of non-trivial hardware, complete documentation is crucial. As an example, in many cases only basic hardware cutsheets are provided. This documentation lacks wiring termination details, pinouts, signal levels, etc. Without this information maintenance becomes much, much, more difficult.

ix. Lack of or non-functioning test equipment such as hand held communication devices, portable computers, and/or diagnostic/operation software.

x. Missing specified and paid for equipment.

xi. Lack of training. Often contractor training, of the O&M mechanics, consists of little more than a Atour@ of the system.

f. Take copious notes. Indicate adjustments that you made during the site visit. Note part and model numbers for devices that need adjustment or replacement.

g. Use data loggers where appropriate as both a diagnostic tool and as a means to quantify and verify the impact of correct performance.

h. Develop Condition Assessment Summary including a description of the benefits/energy cost savings. Each condition assessment will typically yield;

i. A list of deficiencies.
ii. A get-well plan.
iii. A description of the benefits and costs.

Two example CA summaries including the Get Well Plans and benefits are shown in Appendices A and B.

4. References.

1. Dahtzen Chu. "Everything You Always Wanted to Know About Commissioning, But Didn't Know to Ask", U.S. Army Corps of Engineers Electrical Mechanical Conference, 1998.
2. Don Frey. Hardware and Software System For HVAC Lighting

Commissioning, Proceedings of the National Conference on Building Commissioning, April 1993.
3. Portland Energy Conservation, Inc., Summary Report, Third National Conference on Building Commissioning, May 1995.
4. Peter Hertzog, Identification and Quantification of the Improper Operation of Midsize Minnesota Office Buildings on Energy Use: A Seven Building Case Study, Minnesota Building Research Center.
5. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., "Chapter 39 - Building Commissioning", 1995 Applications Handbook, (Atlanta, GA, ASHRAE: 1995).
6. ASHRAE Guideline 1-1996, The HVAC Commissioning Process.
7. CEGS-15950. HVAC Control Systems (SLDC).
8. CEGS-15951. HVAC Control Systems (DDC).
9. CEGS-15995. HVAC Systems Commissioning.
10. Paul C. Tseng, P.E. CEM. "Building Commissioning: Benefits and Costs", Heating, Piping, & Air-Conditioning, April 1998.
11. ER 1110-345-723. Systems Commissioning Procedure, Department of The Army, U.S. Army Corps of Engineers, Office of the Chief of Engineers, CEMP-ET, 31 July, 1995.

BUILDING "A" - AIR TRAFFIC CONTROL BUILDING HVAC SYSTEM
Condition Assessment Summary

1. Occupants report being cold in winter. The heating hot water (HW) system was found to have multiple problems; HW set point was too low, boiler is "on" year round, boiler HW control valve actuator does not work, boiler HW safety flow switch is bypassed, boiler is a constant flow unit but lacks piping to ensure constant flow, all heating system 3-way control valves are piped wrong (including those at the VAV box terminal units), reheat coils in the VAV box terminal units appear to lack the required flow.

2. Control tower, served by AHU-3, is warm thus appears to lack cooling capacity.

3. Preheat coil valve, with actuator closed, leaks a significant amount of water through the coil.

4. Control wiring run in same conduit as 120vac wiring (for heating hot water valve actuator and possibly others).

5. Air handling unit digital controllers had a number of incorrect settings/parameters.

6. Some controllers lose settings/parameters from memory upon power surge.

7. Time clock is not programmed and is not providing on/off control of the air handlers.

8. AHU-1 Motor starter safety shutdown circuit is bypassed using a jumper wire.

9. Freeze stat is indirectly connected to the air handler motor starter circuits.

10. Pitot tube airflow measurement array (AFMA) in outside air duct serves no useful purpose.

11. Outside air duct has no filter. The preheat coil collects debris and may eventually block flow.

12. Outside air (OA) balancing dampers are wide open suggesting that they may not have been balanced or that there is inadequate OA ventilation flow.

13. AHU-1 return air duct had a large piece of ceiling tile (10"x24") sucked into the RA inlet blocking approximately 80% of the duct.

14. AHU-1 air flow is 25% less than the design flow. (Prior to removal of tile blocking RA duct)

15. There is no written sequence describing AHU-1 and AHU-2 duct pressure control or VAV box temperature controls.

16. AHU-3 (Control Tower) has no written sequence of control.

17. VAV box air flow coefficients are suspect because flow measured by box controllers does not agree very well with flow measured using a flow hood.

18. Many indicators on display panel (in 1st floor mechanical room) are not calibrated.

BUILDING "A" - AIR TRAFFIC CONTROL BUILDING HVAC SYSTEM

Get Well Plan

A. In light of all the problems with the heating hot water (HW) boiler/system, it might be wisest and most expedient to leave the HW **System Supply Temperature Controller** (TC-42), (located in the temperature control panel) disabled (as is presently the case) and simply operate the boiler at a constant HW temperature using the Johnson Controls System 350 controller (located in the boiler enclosure). At the same time, increase the **System 350 Controller** set point from the present 150 degrees F to 180 degrees F to increase the system heating capacity approximately 25%. Use the OA reset controller.

B. Rewire the **Outdoor Air Temperature Controller** (TC-41) and the **Preheat Temperature Controller** (TC-10) (both located in the temperature control panel) so that as the outside air temperature decreases the set point of the **Preheat Temperature Controller** (TC-10) increases to a maximum of 65 degrees (as opposed to the present year-round "fixed" set point of 55 degrees). This will increase overall system heating capacity.

C. Adjust the **Outdoor Air Temperature Controller** (TC-41) (located in the temperature control panel) so that it turns the boiler off below 60 degrees F and on above 61 degrees F.

D. Troubleshoot the preheat coil valve actuator to determine if it can be fully closed. Check zero adjustment on actuator.

E. Adjust all controller settings/parameters. Develop configuration checksheets to simplify re-entry of controller settings in the event the settings are lost (such as during a power surge). Obtain Facility Manager software (available for free from TCS Basys Controls) to quickly upload/download controller configurations. The Controls Shop has a copy of this software and uses it for other controls).

F. The system time clock has 4 channels. A single channel is dedicated to AHU-1, AHU-2, and the exhaust fan. AHU-2 serves the second floor which is unoccupied between the hours of (appx.) 1630-0600. The building owners are agreeable to shutting down AHU-2 during the unoccupied hours. Rewire the time clock to place AHU-1 and AHU-2 on separate circuits and make the exhaust fan come on when either AHU-1 or 2 is on.

G. Troubleshoot AHU-1 motor starter safety shutdown circuit and remove jumper wire.

H. Remove the air flow measurement array (AFMA) from the outside air duct (as it serves no useful purpose) and install an air filter to protect the preheat coil. This might best be accomplished by outside contract and will require development of a statement of work.

I. Write a sequence of control describing AHU-1 and AHU-2 duct pressure control and VAV box temperature controls and AHU-3 (Control Tower) controls.

J. Balance the air side of AHU-1, AHU-2 and AHU-3 (including VAV boxes and outside air flows) to ensure that design flows are met. Include confirmation that the VAV box air flow coefficients are correct. This might best be accomplished by outside contract and will require development of a statement of work. Re-check heating system during heating season.

K. Check balance of chilled water system.

L. Install duct temperature gages in AHU-1, AHU-2, and AHU-3. Replace the faulty temperature gage in the heating HW supply line. Install a strap-on temperature gage on the heating HW return line. Disable the display panel in the 1st floor mechanical room since most indicators are faulty/not calibrated and the panel is maintenance intensive.

M. Document all modifications. Review system with O&M staff.

Benefits

- Significant improvement in occupant comfort
- Energy cost savings of approximately $2,500 per year
- Extended equipment life (boiler and AHU-2)
- Life safety / code violations identified
- Improved and simplified O&M due to information transfer and development of complete set of system documentation

BUILDING "B" - TRAINING CENTER HVAC SYSTEM
Condition Assessment Summary

1. Primary air handling unit hot water and chilled water coil valve actuators are not sequenced properly. Heating and cooling can occur at the same time.

2. Cooling coil valve actuator does not modulate. The crankarm is not tightened to the shaft. The valve remains half open. A degree of flow modulation is achieved because the coil bypass butterfly valve does modulate from the control signal.

3. Both butterfly valves on the chilled water cooling coil have actuators in addition to a mechanical linkage between the two. This can cause torque/actuation problems.

4. It appears that the controllers have not been tuned because all PID mode constants are identical in the modulating controllers.

5. Economizer likely does not function properly possibly due to improper placement of the return air sensor.

6. Mixed air (MA) sensor is placed straight/horizontally across duct (downstream of filters), not serpentined, resulting in inaccurate MA temperature measurement due to severe air stratification.

7. Heating hot water boilers and boiler circulating (primary) pumps are manually overridden to "on" at control panel although both boilers are switched "off" at the boilers (circ pumps continue to run).

8. Heating hot water circulating (secondary) pump is manually overridden to "on" at control panel although both boilers are switched "off" at the boilers. Recommend reviewing sequence of operation with O&M staff (Leave pump switch in "auto" position).

9. Air handler is overridden to continuous occupied (on) mode via "Auto Override" push button on face of control panel and at override button on the face of the time clock.

10. Two of four exhaust fan variable speed drives were tripped off on overload.

11. Minimum outside air quantity is probably excessive. Logged data indicates it is about 40% of total supply air flow.

12. Sensor calibration accuracy is in question. Two outside air temperature sensors differ by 3 degrees F. Recommend performing sensor calibration accuracy check.

13. Supply air duct static pressure set point of 1.4 inch water column (iwc) is not maintained late in the day. It is not clear that 1.4 iwc set point is necessary.

14. Vacuum pump compressor is cycling excessively (every 4 minutes).

15. Supply air duct has fairly large leak at split on top of duct where air handler fan cabinet connects to supply air duct.

16. Heating coil is downstream of the cooling coil, in contrast to the design drawings.

17. The VAV boxes are difficult to maintain. Each has an air filter and circulation fan.

BUILDING "B" - TRAINING CENTER HVAC SYSTEM

Get Well Plan

A. Check hot water coil and chilled water coil valve actuator specs to see if the actuators can be adjusted to modulate in sequence. If not, replace with proper actuators. Tighten the crankarm on the chilled water valve shaft or repair the valve(s) to achieve full (90 degree) modulation.

B. Both butterfly valves on the chilled water cooling coil have actuators in addition to a mechanical linkage between the two. This can cause torque/actuation problems. Recommend either disengaging one actuator (if a single actuator can provide enough torque to drive both valves) or remove the mechanical linkage.

C. Tune the PID controllers. Particularly the duct static pressure controller and the heating/cooling (mixed air temperature) controller.

D. Move return air (RA) sensor to far upper right corner of mixed air section where RA dumps directly on sensor.

E. Serpentine mixed air sensor across duct to get better average of mixed air temperature.

F. Perform duct traverse and adjust minimum outside air quantity.

G. Repair split in duct on top of air handler where fan cabinet connects to supply air duct.

H. Compare automatic control modes (on/off) of air handler, boilers, and circulating pumps to design sequence of control and actual needs of building operation. Adjust control mode switches on control panel and take time clock out of override mode.

I. Reset two exhaust fan variable speed drives that are tripped off on overload.

J. Check air balance report to assess need for supply air duct static set point of 1.4 iwc.

K. Perform function performance test on 10% of VAV box terminal units to determine if they are performing properly. As part of this, check with building operations supervisor to identify possible problematic VAV boxes.

L. Check calibration of all air handler and heating system sensors.

M. Repair/modify mixed air economizer.

N. Document all modifications. Review system with O&M staff.

Benefits

- Improvement in occupant comfort
- $7000 energy cost savings for recommissioning of economizer, split duct, and proper sequencing of CHW and HW coil valves. Potential for an additional $10,000 for approximately 7 hours of night setback (turn AHU off).
- Extended equipment life
- Improved and simplified O&M due to information transfer and development of complete set of system documentation

TYPICAL SETPOINTS and PID TUNING CONSTANTS
FOR COMMON HVAC CONTROL LOOPS

(14 April 99)

GENERAL. The controller settings described here apply primarily to single-loop digital controllers and are provided as guidelines only. Control setpoints ordinarily are designer selections and should be shown/found on the control system AEquipment Schedule@ drawing. PB and I may need to be adjusted, beyond the initial settings shown below, as part of the controller tuning process.

<u>Setpoint</u> (**SP**) is the value of a process variable (PV) that a control loop is to maintain.
<u>Throttling Range</u> (**TR**) is the amount of change in the process variable that causes the controller output to move full range (4-20mA). Suggested values are shown below.
<u>Proportional Band</u> (**PB**) tuning constant, in units of percent of sensor span, to be entered into the controller depends on the TR for the application and is calculated as:

PB = TR x 100 / SensorSpan

<u>Integral</u> (**I**) tuning constant is shown in units of seconds per repeat.
<u>Derivative</u> (**D**) tuning constant = zero (don=t need it in HVAC control).

PREHEAT COIL DISCHARGE AIR TEMPERATURE CONTROLLER

SP = 40EF when the sensor is located in the outside air duct.
SP = 55EF when the sensor is located in the mixed air section, supply air duct, or when the coil is in a 100% outside air system (i.e. when there is no return duct).
TR = 25EF, I = 60 seconds

COOLING COIL DISCHARGE AIR TEMPERATURE CONTROLLER

SP = 55E to 60E F. Depends on the HVAC system design.
TR = 25EF, I = 60 seconds

HEATING COIL DISCHARGE AIR TEMPERATURE CONTROLLER

SP = Between 80E and 115EF. May be automatically adjusted (reset) based on outside air temperature.
TR = 25EF, I = 60 seconds

MIXED AIR TEMPERATURE CONTROLLER

SP = 52E to 58EF. Usually set 2E to 3E F below the cooling coil discharge air temperature setpoint to compensate for the temperature rise across the supply fan.
TR = 25EF, I = 30 seconds

DRY BULB ECONOMIZER CONTROLLER

<u>Two conditions</u> must be met in order for the Economizer Controller to activate the economizer mode:

1. PV contact setpoint: There must be a cooling demand as indicated by a warm return air temperature. If the return air temperature is above about **73^{o} F**, there is a probable demand for cooling. This is the PV contact setpoint.
2. DEV contact setpoint: The outside air must be cool enough to supply free cooling so it is necessary for the outside air temperature to be lower than the return air temperature by a difference (DEV) great enough to ensure that the enthalpy (heat content) of the outside air is less than that of the return air. This is a design calculation based on the particular climatic location. Typical DEV contact setpoints:
   - -Dry climate: 1E to 2EF, Moderate climate: 4E to 6EF, Humid climate: 8E to 12EF

SUPPLY DUCT STATIC PRESSURE CONTROLLER

SP = 0.8 to 1.0 inch water column (iwc). The setpoint should equal the sum of the minimum static pressure required at the inlet of the VAV terminal units and the pressure loss in the ductwork between the sensor and the most remote VAV terminal unit at the maximum air flow rate. During system balancing, the optimum setpoint can be established by lowering the setpoint value to the lowest possible setting at which the most remote VAV terminal unit will continue to function properly. A high limit static pressure sensor is often provided in the ductwork immediately downstream of the supply fan to prevent damage to the ductwork in the event of a failure in the fan control loop. Its setpoint depends on the duct classification.
TR = 4 iwc, I = 30 seconds

VAV RETURN AIR VOLUME (CFM) FLOW CONTROLLER

SP is adjusted by the flow sensor located in the supply air duct. The return fan flow controller subtracts (biases) a certain amount of cfm from the supply air flow sensor signal to establish the setpoint of the return fan flow controller. The controller Bias parameter should be set equal to the total cfm of space exhaust fans + 10% of the design supply air cfm flow (As a negative number). The Ratio parameter accounts for differences in flow sensor ranges and duct areas where the flow stations are installed. Ratio = (SA air sensor range / RA air sensor range) x (SA duct area / RA duct area)
TR = 2 x design supply air cfm flow, I = 30 seconds

MINIMUM OUTSIDE AIR VOLUME (CFM) FLOW CONTROLLER

SP = whichever is larger:

1. Total cfm of space exhaust fans + 10% of design supply air cfm flow, or
2. Fresh air ventilation cfm flow (based on ASHRAE standard 62)

TR = 2 x SP, I = 30 seconds

SPACE HUMIDITY CONTROLLER

SP = 45 to 55% RH
TR = 10% RH, I = 120 seconds

DUCT HUMIDITY HIGH LIMIT CONTROLLER

SP = 90% RH, TR = 20% RH, MR = 50% (or 12mA)
These settings cause the humidifier valve to begin to close at 80% RH and to be full closed at 90% RH when the valve actuation range is 10-15 psi (13.3 mA - 20 mA).

SINGLE ZONE TEMPERATURE CONTROLLER

Adjustable Setpoint = 68EF during the heating season and 78EF during cooling season. Computer rooms, critical areas of hospitals, labs, etc., setpoints will usually be maintained between 72E to 75EF year around.
TR = 4EF, I = 0

NIGHT STAT

SP = 45^{o} F to 55^{o} F (depending on system). The setpoint depends on time required to achieve temperature recovery when the AHU is started back up, material storage requirements, and keeping the building warm enough prevent mechanical systems from freezing during unoccupied mode.

HEATING HOT WATER TEMPERATURE CONTROLLER

SP = 100E to 180E F. May be automatically adjusted (reset) based on outside air temperature. Boiler igniter/flame controller setpoint=180E F. Never less than 130E F.
TR = 30EF, I = 60 seconds